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Relative Value of Different Sands for Making Mortar

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RELATIVE VALUE

OF

DIFFERENT SANDS FOR MAKING MORTAR

BY

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This is to certify that the following thesis prepared under the immediate direction of Mr. C. C. Wiley, Instructor in Civil Engineering, by

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entitled RELATIVE VALUE OF DIFFERENT SANDS FOR MAKING MORTAR

is accepted by me as fulfilling this part of the requirements for the Degree of Bachelor of Science in Civil Engineering.

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Introduction

Of recent years concrete has been recognized as one of the best materials for building purposes. Formerly, and even at the present time, structural steel and natural stone were considered as the standard building materials; but they are being rapidly replaced by reinforced concrete for many purposes. For example, in Chicago there is a building now under construction which will cost about $5,000,000 and which is being built almost entirely of reinforced concrete. Owing to this increasing use concrete has come to be studied with a good deal of care in order to determine the best materials of which to make it and the proportions in which they should be mixed.

Concrete, as is well known, consists of an aggregate of crushed rock, gravel, or similar material embedded in cement mortar. The greater amount of study has been to determine the best material for the aggregate and the proportion of it used with a given amount of mortar but for some reason the study of the mortar itself and its relation to the

mass has been neglected. Specifications usually require that concrete shall consist of so many parts of cement to so many parts of "clean sharp sand" and so many parts of "aggregate" whatever it may be and this is about as far as the matter of sand is looked after. Experiments have shown that even "Clean sharp sands" vary in cleanness, and in size of grains and that these variations effect the mortar made of them, and of a necessity must effect the concrete in which they are used. However in certain locations only certain sands are available and therefore are in common use.

With a view of discovering how the sands used for building purposes in the different cities of Illinois compared in strength, letters of request were sent to the city engineers of about twenty cities for a fairly representative sample of the sands used. The following cities responded as follows:—

Sample No.	City obtained from.
1, 2, 3 & 4	Chicago
5 & 6	Elgin
7	Bloomington

8	Rockford
9, 10 & 11	Springfield
12	Champaign
13	Galesburg
14	Decatur
15 & 16	Freeport
17	Aurora
18	Joliet
19	Moline
20	Champaign

All of these samples were sand except samples #4 & #15 which were crushed limestone screenings and crushed sandstone screenings, respectively. A majority of the sands used in the different cities were local sands, but some cities used sands obtained from a distance; and therefore in the tables showing the results of the tests both the city furnishing the sand and the location from whence the sand was obtained will be given.

Tests were made for the tensile strength, fineness, and for cleanness or finding the amount of clay in the sand.

The tensile strength of the mortar was found as this is the usual method

for determining the value of cement mortar, and it has been found that the tensile strength of mortar does not vary as much as the compressive strength.

The fineness of the sand was determined because experiments show that sand which has a variety of sizes makes the strongest mortar because the grains interlock and the per cent of voids is reduced.

It has been shown that when the amount of clay in mortar becomes more than 6% it materially reduces the strength of the mortar (See thesis entitled "Effect of Clay on Strength of Concrete" by B. H. Prater, U. of I. 1903.), and therefore the amount of clay in the sands were determined.

Tensile Strength.

The tensile strength was first determined. In order that the element of time would not effect the results, it was decided to make a certain number of briquettes and break an equal number in 7 days, 28 days, and 90 days respectively, and in order to reduce the probable error in the results it was thought best to make 10 briquettes for each age as the more briquettes tested,

the less error there would be in the general result.

The cement used was Chicago AA Portland and the mixture was one part cement to three parts sand by weight. The quantity of water used in every case was 10% of the dry material.

After some preliminary experimenting in order to determine the best method of moulding the briquettes, the method recommended by the Am. Soc. C. E., (1904), was adopted. Essentially, it consists of filling the moulds with mortar and troweling on both sides using considerable pressure. The method of procedure was as follows:— The sand was first weighed and then carefully mixed dry on a slate table with the cement which had also been weighed. The 10% of water was added and the mixture was worked with a trowel until it had the proper consistency. The moulds were then filled completely, pressing in slightly with the hands and then well troweled using considerable pressure. The moulds were then turned over and the briquettes troweled in a like manner on the other side. The briquettes

were then allowed to stand in the air covered by a damp cloth for 24 hours when they were removed from the moulds, placed in water which was changed frequently, and left until they were to be tested.

The briquettes were broken in a Falkneaw-Sinclair Automatic Cement Testing Machine, applying the load at the rate of 600 pounds per minute as recommended by the report of the Am. Soc. C. E. Committee on "Standard Methods for Testing Cement."

Twenty samples were tested and thirty briquettes were made for each sample except for the crushed rock samples for which only twenty briquettes were made. An equal number of briquettes were tested at three different ages, viz., 7, 28, and 90 days, making in all 60 tests requiring 580 briquettes. The results of tests are shown in the tables on pages 14 to 33 inclusive.

Fineness.

The fineness of the sand was next determined. The sand was first screened through a 1/4" sieve to remove the pebbles, this being the common practice in making mortar and concrete, and then it was

placed in an oven, where it was left for 24 hours to remove the moisture. The sieves were arranged in the following order:— The pan was placed first at the bottom, then the #100, #24, #16, #12 #8 sieves were placed in order above it. 1000 grams of the sand was then placed in the #8 sieve, which was on top, and shook thoroughly for one hour. This caused the finer sand to gradually sift through until it was caught on the finer sieves or in the pan. The amount of sand retained on the different sieves and in the pan was carefully weighed and the per cent. of sand retained on each sieve was then determined. The results are shown in the tables, pages 14 to 33 inclusive.

The object of this test was to discover which is the preferable, coarse or fine sands and whether it is better to have the sand all of one size or to have a variety of sizes. Eighteen samples were tested. The fineness of the crushed rock screenings was not determined.

Test For Clay.

The sand was passed through a $\frac{1}{4}$"

sieve and placed in the oven to dry. It was left in the oven for 24 hours. 1000 grams were then weighed out and placed in a pail, and water from a faucet was allowed to flow slowly over it. At the same time the sand was washed with the hands. The sand, being heavier than the water, remained in the bottom of the pail but the clay which was finely divided was held in suspension and flowed over the top of the pail with the water. Since some of the fine sand would also be washed over with the clay, a pan was placed under the pail to catch it. The sand was washed until the water became clear which showed that all the clay had been removed. This operation required from a half hour to an hour and a half depending on the amount of clay mixed with the sand. The sand was then placed in an oven and allowed to remain 48 hours or until all the moisture was evaporated. It was then weighed and the difference between this weight and the 1000 grams showed the amount of clay in the sand. From this

data the per cent of clay in each sand was determined. Eighteen sands were tested for clay.

Description of Tables

Pages 14 to 33 inclusive show tables giving the results of the various tests, Viz., tensile fineness and cleanness. In the upper right hand corner the place the sand was received from is shown while directly under it, the place where the sand was obtained is given. To the left of this is given the sample No. of the sand. The first test recorded is for the tensile strength. In it is shown the strength of each briquette for the three different ages and also the average strength of the briquette for each age. Below the table for tensile strength is the table for fineness. This shows the quantity passing and retained on each of the sieves and also the per cent. retained on each sieve. The total amount of sand used in each case is given.

Beneath the table for fineness the per cent. of clay in each sand is recorded.

Tables 34 to 35 inclusive shows the average fineness, the per cent. of clay contained in the

sand and the tensile strength of the mortar at the age of 28 days. The average fineness was obtained in the following manner:— The per cent. passing each sieve and retained by the next was multiplied by the sieve no. and this total divided by 100 gave the average fineness or the weighted mean of the fineness. Sand one will be taken as an example.

No. Sieve		% passing sieve	
4	x	0.0 =	0.00
8	x	0.0 =	0.00
12	x	0.01 =	.12
16	x	0.18 =	2.90
24	x	99.50 =	2388.00
100	x	0.31 =	31.00
			2422.02

2422.02 ÷ 100 = 24.2 Average fineness.

Plate I shows a curve for which the per cent. of clay was taken as the ordinates and the tensile strength, at the age of 28 days, as the abscissae. The sands used for plotting this curve had the same average fineness but the per cent. of clay varied. Plate II shows a curve for which the average fineness was taken as ordinates and the tensile strength, at the age of 28 days, as abscissae.

the per cent. of clay in the different sands in this case was constant.

Conclusion.

The curve on Plate I seems to indicate that the tensile strength varies inversely as the per cent. of clay in the sand which agrees with previous experiments (see reference page 4). The curve on Plate II indicates that the tensile strength varies inversely as the average fineness. When both factors are present the sand is usually unsuitable for construction work.

The two poorest sands were from Joliet and Bloomington. The cause of their weakness was the large per cent. of clay each contained and also their extreme fineness. However since the fineness was determined with the clay in the sand the clay also effects the fineness. The Chicago, Moline and Galesburg sands were clean but they were very fine so this accounts for their low tensile strength. The Chicago limestone screenings had a variety of sizes and they were also clean which with their irregular shapes caused their high tensile strength. The sands from Aurora, Mound City Ind. (used in Champaign), Elgin, Decatur and Rockford were all practically clean and the tables show

that these sands were fairly coarse. Champaign (local) sand was pretty coarse but it had a large amount of clay in it which lowered the tensile strength. The Alton, Freeport and Lincoln sands were fairly clean but they were pretty fine, although not as fine as the Chicago sands. They were therefore stronger.

From the results of the tests the different sands are arranged according to their strength as follows:

	Name	Tensile Strength Age 28 days
1	Chicago Limestone screenings	273#
2	Aurora sand	270#
3	Stipe's Sand Champaign	261#
4	Elgin Sand-Hammond Pit	240#
5	" " -Stimpson "	222#
6	Decatur sand	221#
7	Rockford "	211#
8	Champaign "	193#
9	Alton "	183#
10	Lincoln "	175#
11	Freeport "	164#
12	" Sandstone screenings	164#
13	Chicago sand	163#
14	Alton "	160#
15	Galesburg "	139#
16	Moline "	138#
17	Chicago "	129#
18	" "	115#
19	Bloomington "	101#
20	Joliet "	93#

From the above it appears that the sands obtained in Illinois are, on the average, suitable for building purposes. In a few cases, Champaign for example, the sand was not considered suitable for use and sand was obtained from other states or cities.

RESULTS OF TESTS

Sample No. 1 — Received from Chicago
Obtained " "

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per square inch		
	Age 7 days	Age 28 days	Age 90 days
1	90	140	140
2	80	140	140
3	80	120	135
4	75	140	140
5	60	140	140
6	75	130	125
7	80	120	130
8	90	120	150
9	60	120	130
10	60	120	130
Average	75	129	136

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
# 8	0	1000	0
# 12	0	1000	0
# 16	.1	999.9	.01
# 24	1.8	998.1	.18
# 100	995.0	3.1	99.50
Pan	3.1	0.0	.31
Total	1000		100.

TEST FOR CLAY

2.75 parts clay in 1000 parts = .275 % Clay

RESULTS OF TESTS

Sample No. 2 — Received from Chicago
Obtained " "

TENSILE STRENGTH

Ref No.	Breaking Strength pounds per square inch		
	Age 7 days	Age 28 days	Age 90 days
1	115	140	150
2	80	70	160
3	90	140	170
4	105	120	160
5	90	90	140
6	90	130	110
7	90	120	150
8	80	100	130
9	90	100	150
10	90	140	120
Average.	92	115	144

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
# 8	13.4	986.6	1.34
# 12	10.3	976.3	1.03
# 16	16.4	959.9	1.64
# 24	30.1	929.8	3.01
# 100	924.4	5.44	92.44
Pan	5.4	0.0	.54
Total	1000.		100.

TEST FOR CLAY

3 parts clay in 1000 parts = .3% clay

RESULTS OF TESTS

Sample No.3 Received from Chicago
Obtained " "

TENSILE STRENGTH

Ref No.	Breaking Strength pounds per square inch		
	Age 7 days	Age 28 days	Age 90 days
1	110	220	200
2	120	160	160
3	140	160	150
4	110	160	140
5	110	180	160
6	110	150	180
7	130	150	180
8	110	150	180
9	130	150	140
10	120	150	150
Average	119	163	164

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
# 8	80	920	8.0
# 12	33.9	886.1	3.39
# 16	36.1	850.0	3.61
# 24	67.0	783.0	6.7
# 100	780.0	3.0	78.0
Pan	3.	0.0	.3
Total	1000.		100.

TEST FOR CLAY

3.1 parts clay in 1000 parts = .31% clay

RESULTS OF TESTS

Sample No. 4 (Limestone Screenings)

Received from Chicago
Obtained " "

Ref No.	Breaking Strength pounds per square inch		
	Age 7 days	Age 28 days	Age 90 days
1	100	320	250
2	120	220	235
3	80	330	190
4	160	240	230
5	110	255	430
6			290
7			340
8			250
9			190
10			370
Average	114	273	277.5

RESULTS OF TESTS

Sample No. 5 Received from Elgin
Obtained " ", Hammond Pit

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per Square inch		
	Age 7 days	Age 28 days	Age 90 days
1	170	190	280
2	150	250	290
3	190	285	410
4	160	260	360
5	180	240	260
6	160	215	280
7	150	305	260
8	170	260	260
9	160	220	300
10	170	260	260
Average	166	249	296

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
#8	124.6	875.4	12.46
#12	99.4	776.0	9.94
#16	108.6	667.4	10.86
#24	144.1	523.3	14.41
#100	512.9	10.4	51.29
Pan	10.4	0.0	1.04
Total	1000		100

TEST FOR CLAY

9.7 parts clay in 1000 parts = .97% Clay

RESULTS OF TESTS

Sample No 6 Received from Elgin
Obtained " ", Stimpson Pit

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per square inch Age 7 days	Age 28 days	Age 90 days
1	140	205	240
2	150	190	230
3	130	255	360
4	120	160	290
5	140	200	215
6	120	295	290
7	110	250	200
8	130	220	260
9	170	220	265
10	160	225	300
Average	137	222	265

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
#8	35	965	3.5
#12	50	915	5.0
#16	95	820	9.5
#24	182	638	18.2
#100	623	15	62.3
Pan	15	0	1.5
Total	1000		100.

TEST FOR CLAY

8.7 parts clay in 1000 parts = .87% Clay

RESULTS OF TESTS

Sample No 7 Received from Bloomington
Obtained " "

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per Square inch Age 7 days	Age 28 days	Age 90 days
1	80	120	170
2	80	100	170
3	80	95	155
4	120	65	145
5	120	75	120
6	110	90	120
7	90	115	120
8	120	100	160
9	60	110	170
10	60	140	180
Average	92	101	151

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
# 8	92	918	9.2
# 12	71	847	7.1
# 16	96	741	9.6
# 24	130	611	13.0
# 100	545	66	54.5
Pan	66	0.0	6.6
Total	1000		100.

TEST FOR CLAY

63.8 parts clay in 1000 parts = 6.38% clay

RESULTS OF TESTS

Sample No 8 Received from Rockford
Obtained " "

TENSILE STRENGTH

Ref. No	Breaking Strength, pounds per square inch Age 7 days	Age 28 days	Age 90 days
1	140	260	200
2	140	220	220
3	170	240	220
4	140	190	180
5	200	200	210
6	180	190	220
7	200	200	240
8	140	190	220
9	180	160	220
10	180	260	250
Average	167	211	218

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
#8	35	965	3.5
#12	52	913	5.2
#16	104	809	10.4
#24	276	533	27.6
#100	522	11	52.2
Pan	11		1.1
Total	1000		100.

TEST FOR CLAY

6 parts clay in 1000 parts = .6% Clay

RESULTS OF TESTS

Sample No 9 Received from Springfield
Obtained " Lincoln

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per square inch Age 7 days	Age 28 days	Age 90 days
1	130	180	260
2	140	180	260
3	140	170	220
4	150	220	170
5	130	195	210
6	160	195	220
7	130	180	230
8	120	170	220
9	110	160	240
10	140	180	260
Average	132	183	229

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
#8	53.0	947	5.3
#12	96.0	851	9.6
#16	112.0	739	11.2
#24	154.0	585	15.4
#100	580.0	5	58.0
Pan	5.0		.5
Total	1000.0		100.0

TEST FOR CLAY

11 parts clay in 1000 parts = 1.1% clay

RESULTS OF TESTS

Sample No. 10 — Received from Springfield
Obtained " Alton

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per Square inch Age 7 days	Age 28 days	Age 90 days
1	120	165	220
2	140	160	200
3	130	160	200
4	110	140	200
5	160	200	200
6	110	160	180
7	100	140	200
8	120	150	180
9	100	175	200
10	110	150	190
Average	120	160	197

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
# 8	19	981	1.9
# 12	18	963	1.8
# 16	38	925	3.8
# 24	129	796	12.9
# 100	793	3	79.3
Pan	3		.3
Total	1000		100.

TEST FOR CLAY

3 parts clay in 1000 parts = .3% clay

RESULTS OF TESTS

Sample No. 11 Received from Springfield Obtained " Alton

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per square inch Age 7 days	Age 28 days	Age 90 days
1	130	185	220
2	160	160	200
3	155	160	190
4	130	150	240
5	145	180	200
6	140	170	200
7	145	180	190
8	120	150	220
9	160	220	200
10	165	195	210
Average	145	175	207

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
#8	19.2	980.8	1.92
#12	26.2	954.6	2.62
#16	50.9	903.7	5.09
#24	160.7	743.0	16.07
#100	740.0	3.0	74.00
Pan	3.0		.30
Total	1000.0		100.00

TEST FOR CLAY

2.1 parts clay in 1000 parts = .21% clay

RESULTS OF TESTS

Sample No 12

Received from Champaign
Obtained " Mound City Ind. (Stypes)

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per square inch		
	Age 7 days	Age 28 days	Age 90 days
1	220	240	340
2	205	220	240
3	205	290	260
4	250	230	370
5	210	230	310
6	235	230	340
7	170	225	300
8	205	315	360
9	250	330	310
10	250	300	280
Average	220	261	315

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
# 8	92.0	908.0	9.20
# 12	135.1	772.9	13.51
# 16	167.0	605.9	16.70
# 24	208.0	397.9	20.80
# 100	379.0	18.9	37.90
Pan	18.9		1.89
Total	1000.0		100.00

TEST FOR CLAY

15 parts clay in 1000 parts = 1.5% clay

RESULTS OF TESTS

Sample No. 13 — Received from Galesburg
Obtained " "

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per square inch		
	Age 7 days	Age 28 days	Age 90 days
1	115	155	190
2	90	135	200
3	105	100	160
4	100	155	200
5	90	135	160
6	100	140	160
7	100	145	170
8	90	155	170
9	100	140	160
10	100	130	180
Average	99	139	175

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
#8	2.3	997.7	.23
#12	2.3	995.4	.23
#16	5.6	989.8	.56
#24	30.8	959.0	3.08
#100	958.0	1.0	95.80
Pan	1.0		.10
Total	1000.0		100.00

TEST FOR CLAY

3 parts clay in 1000 parts = .3% clay

RESULTS OF TESTS

Sample No. 14 Received from Decatur
Obtained " "

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per square inch		
	Age 7 days	Age 28 days	Age 90 days
1	230	210	360
2	180	230	380
3	250	310	300
4	190	210	340
5	180	180	280
6	190	280	280
7	230	190	280
8	180	160	300
9	210	210	290
10	180	230	340
Average	202	221	315

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
#8	220	780	22.0
#12	140	640	14.0
#16	160	480	16.0
#24	126	354	12.6
#100	349	5	34.9
Pan	5		.5
Total	1000		100.0

TEST FOR CLAY

21 parts clay in 1000 parts = 2.1% clay

RESULTS OF TESTS

Sample No. 15

Received from Freeport
Obtained " "

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per square inch		
	Age 7 days	Age 28 days	Age 90 days
1	160	145	280
2	145	90	260
3	140	135	220
4	150	140	230
5	130	210	250
6	175	250	260
7	150	180	240
8	160	175	250
9	120	155	250
10	120	160	240
Average	145	164	248

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
#8	12	988	1.2
#12	38	950	3.8
#16	73	877	7.3
#24	142	735	14.2
#100	722	13	72.2
Pan	13		1.3
Total	1000		100.0

TEST FOR CLAY

23 parts clay in 1000 parts = 2.3% clay

RESULTS OF TESTS

Sample No. 16 Received from Freeport
(Sandstone Screenings) Obtained " "

TENSILE STRENGTH

Ref No.	Breaking Strength pounds per square inch		
	Age 7 days	Age 28 days	Age 90 days
1	130	160	240
2	130	150	250
3	130	200	230
4	120	150	200
5	130	150	220
6			220
7			260
8			200
9			240
10			230
Average	128	164	229

RESULTS OF TESTS

Sample No. 17 Received from Aurora
Obtained " "

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per square inch		
	Age 7 days	Age 28 days	Age 90 days
1	190	220	315
2	240	260	410
3	170	220	385
4	220	200	270
5	170	310	300
6	170	270	300
7	170	350	320
8	210	340	360
9	200	240	320
10	220	290	300
Average	196	270	328

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
# 8	41	959	4.1
# 12	98	861	9.8
# 16	142	719	14.2
# 24	211	508	21.1
# 100	504	4	50.4
Pan	4		.4
Total	1000		100.0

TEST FOR CLAY

5 parts clay in 1000 parts = .5% clay

RESULTS OF TESTS

Sample No. 18 Received from Joliet
Obtained " "

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per square inch		
	Age 7 days	Age 28 days	Age 90 days
1	80	90	140
2	100	105	150
3	110	115	170
4	80	80	180
5	100	90	160
6	90	80	200
7	80	90	190
8	90	95	190
9	90	100	160
10	90	85	200
Average	91	93	174

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
#8	4.5	995.5	.45
#12	4.1	991.4	.41
#16	13.0	978.4	1.30
#24	160.0	818.4	16.00
#100	804.4	14.0	80.44
Pan	14.0		1.4
Total	1000.0		100.00

TEST FOR CLAY

125 parts clay in 1000 parts = 12.5% clay

RESULTS OF TESTS

Sample No. 19 — Received from Moline
Obtained " "

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per square inch Age 7 days	Age 28 days	Age 90 days
1	100	140	140
2	100	130	120
3	90	150	140
4	90	105	120
5	95	140	140
6	105	145	150
7	90	160	120
8	100	150	140
9	110	160	140
10	120	100	120
Average	100	138	133

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
#8	13.3	986.7	1.33
#12	22.1	964.6	2.21
#16	41.2	923.4	4.12
#24	130.0	793.4	13.00
#100	791.4	2.0	79.14
Pan	2.0		.20
Total	1000.0		100.00

TEST FOR CLAY

2 parts clay in 1000 parts = .2% clay

RESULTS OF TESTS

Sample No. 20 Received from Champaign
Obtained " "

TENSILE STRENGTH

Ref. No.	Breaking Strength pounds per square inch Age 7 days	Age 28 days	Age 90 days
1	160	150	320
2	150	170	240
3	150	200	260
4	160	230	300
5	155	180	330
6	145	150	300
7	170	240	310
8	180	220	270
9	170	180	330
10	160	210	360
Average	160	193	302

FINENESS

Standard Mesh	Quantity Retained	Quantity Passing	Per Cent Retained
#8	294.6	705.4	29.46
#12	172.6	532.8	17.26
#16	163.8	369.0	16.38
#24	138.7	230.3	13.87
#100	177.7	52.6	17.77
Pan	52.6		5.26
Total	1000.0		100.00

TEST FOR CLAY

78 parts clay in 1000 parts = 7.8% clay

TABLE SHOWING TENSILE STRENGTH AND PER CENT. OF CLAY. IN SANDS

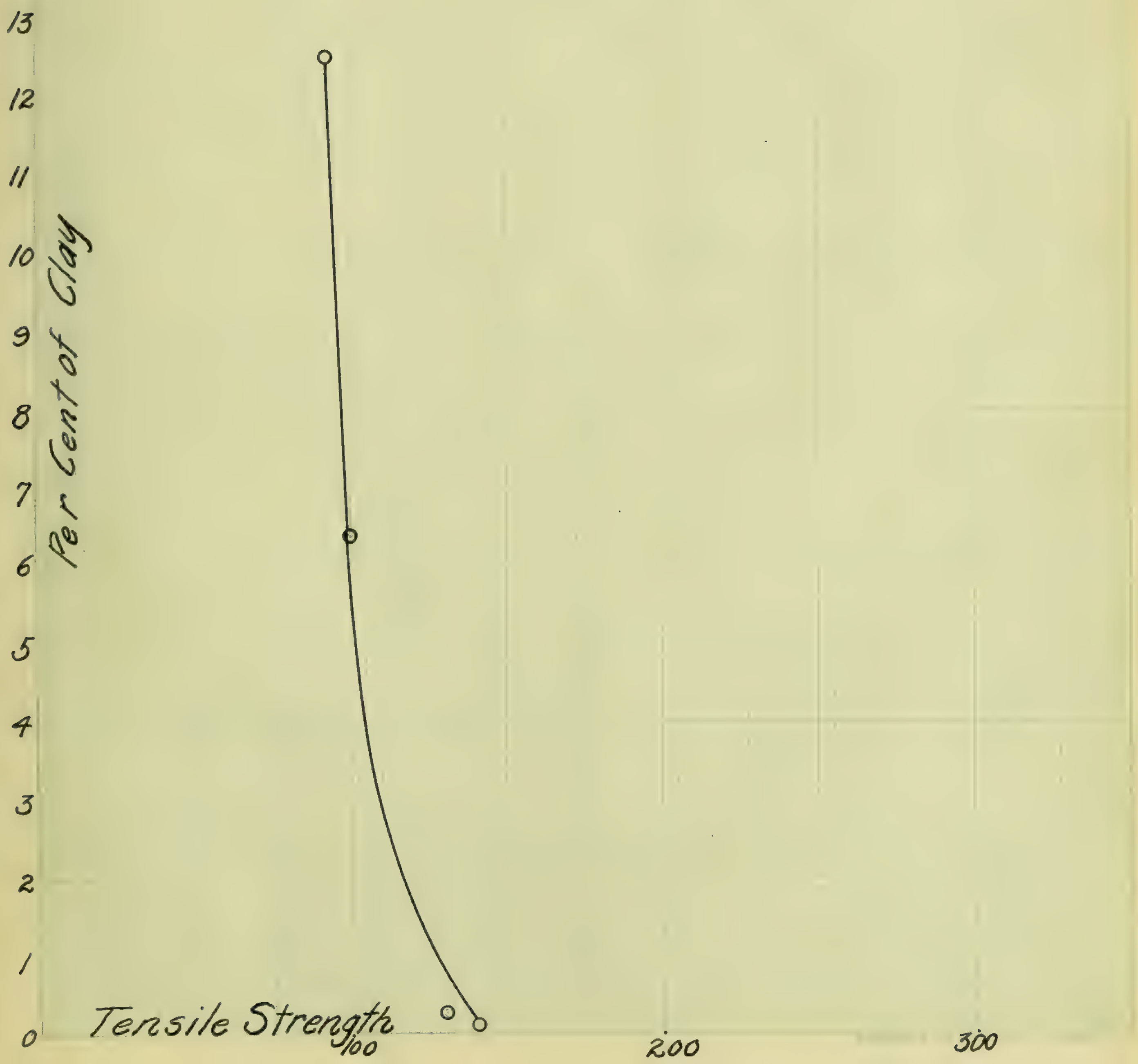
Sample No.	Breaking Strength pounds per square inch Age 28 days	Per Cent. of Clay Contained in Sand
1	129	.275
2	115	.300
3	163	.310
4	273	
5	240	.97
6	222	.87
7	101	6.38
8	211	.60
9	183	1.10
10	160	.30
11	175	.21
12	261	1.50
13	139	.30
14	221	2.10
15	164	2.30
16	164	
17	270	.50
18	93	12.5
19	138	.20
20	193	7.80

TABLE SHOWING TENSILE STRENGTH AND AVERAGE FINENESS OF SANDS

Sample No.	Fineness: % by Weight Caught on Sieve No. 8	12	16	24	100	Pan	Average Fineness	Tensile Strength lbs/sq. in.
1	0	0	.01	.18	99.50	.31	24.3	129
2	1.34	1.03	1.64	3.01	92.44	.54	23.4	115
3	8.0	3.39	3.61	6.7	78.0	.30	20.1	163
4								273
5	12.46	9.94	10.86	14.41	51.29	1.04	18.2	240
6	3.5	5.0	9.5	18.2	62.3	1.5	22.0	222
7	9.2	7.1	9.6	13.0	54.5	6.6	23.8	101
8	3.5	5.2	10.4	27.6	52.2	1.1	19.8	211
9	5.3	9.6	11.2	15.4	58.0	.5	19.1	183
10	19	18	3.8	12.9	79.3	.3	22.1	160
11	1.92	2.62	5.09	16.07	74.00	.3	21.5	175
12	9.2	13.57	16.70	20.80	37.90	1.89	17.8	261
13	.23	.23	.56	3.08	95.80	.1	23.7	139
14	22.0	14.0	16.0	12.6	34.9	.5	14.8	221
15	1.2	3.8	2.3	14.2	72.2	1.3	22.1	164
16								164
17	4.1	9.8	14.2	21.1	50.4	.4	18.5	270
18	.45	.41	1.30	16.00	80.44	1.40	23.9	93
19	1.33	2.21	4.12	13.00	79.14	.2	22.0	138
20	29.46	17.26	16.38	13.87	17.77	5.26	16.3	193

Plate I

Average Fineness Constant
Varying Per Cent of Clay



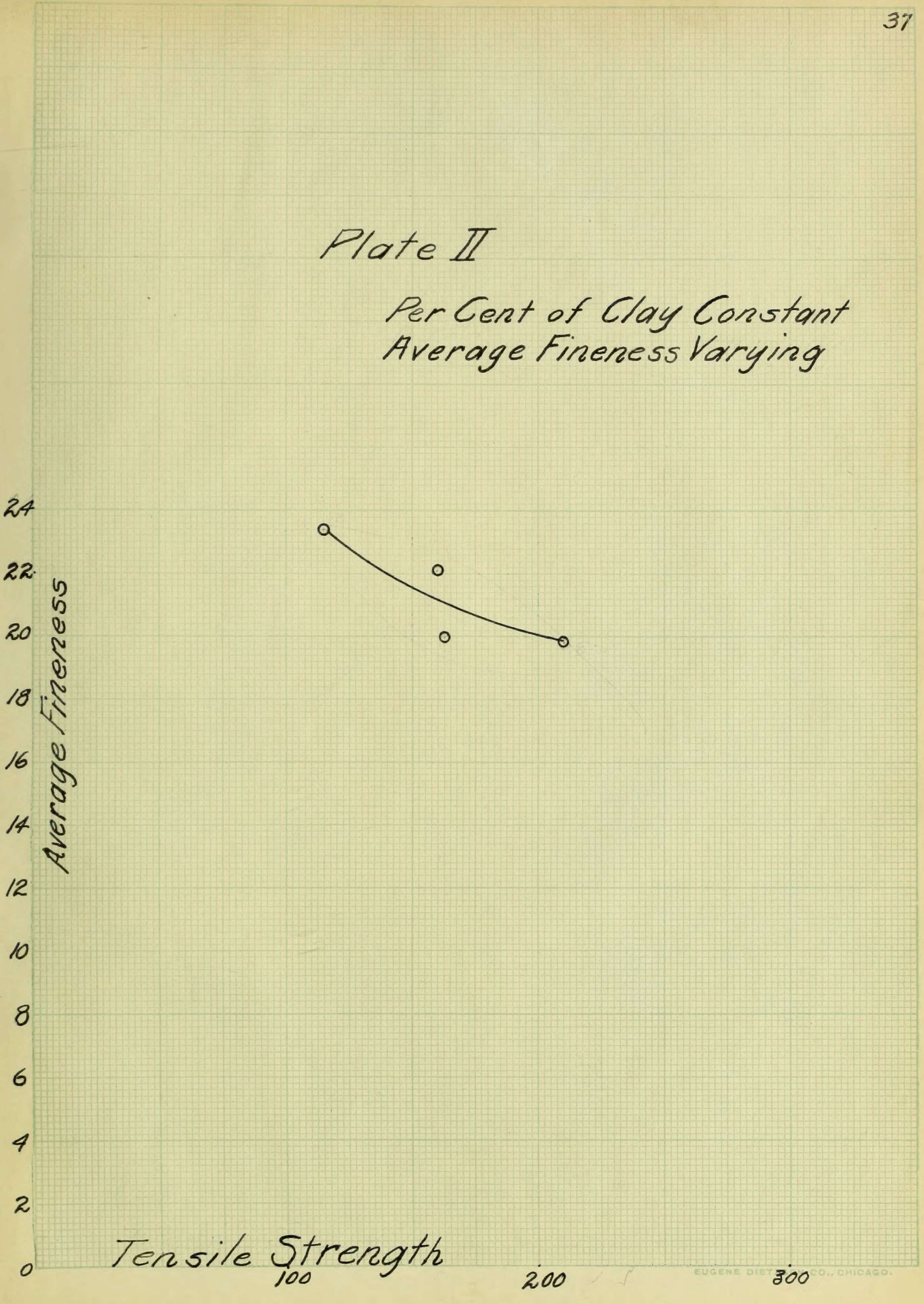


Plate II
Per Cent of Clay Constant
Average Fineness Varying
Average Fineness
Tensile Strength
24
22
20
18
16
14
12
10
8
6
4
2
0
100
200
300